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SPE-P-24-1: Evaluation of Fish Condition for Juvenile Salmonids in Modified Gatewells at the Bonneville Dam's Second Powerhouse

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Outline

- Background
- Objectives
- Methods
  - Descaling and Mortality
  - Treatment Conditions
  - Historical Comparison
  - Treatment Comparison
- Implementation
- Results
- Conclusions

Background: B2 Gatewell Improvements

2001-2007

- VBS and gatewell mods occurring to improve FGE
- Operations span 1% efficiency range
- Descaling and mortality increase noted at high flows with modifications in place

2008-2013

- Larger VBS, gap closure device, and turning vanes in place
- Operations in mid range and lower portion of 1% efficiency range
- Best source of comparison for new configuration

2014-2023

- Configuration changing: Installation and removal of plates, followed by installation of concrete corbels and VBS porosity modifications to manage gatewell flow and turbulence
- Operations in mid range and lower portion of 1% efficiency range

2024

- VBS Porosity Modifications and Concrete Corbel Installation Completed
- Post Construction Evaluation (This Study)

Objectives

1. Create a timeline of B2 gatewell modifications and operations to establish points of comparison.
2. Estimate descaling and mortality percentages for juvenile salmonids (all species combined) sampled in the Bonneville Dam JFF as part of the SMP during turbine unit (modified with corbel and VBS porosity change) operations in the middle and upper end of the 1% peak efficiency range in spring and summer, 2024.
    a. Statistically compare descaling and mortality percentages between mid and upper 1% peak efficiency range (modified with corbel and VBS porosity change) operations separately for spring and summer in 2024 to test the following hypotheses:
        i. Descaling (D): H_0: $D_{upper} = D_{mid}$; H_A: $D_{upper} \neq D_{mid}$
        ii. Mortality (M): H_0: $M_{upper} = M_{mid}$; H_A: $M_{upper} \neq M_{mid}$
    b. Non-statistically compare descaling and mortality percentages observed in 2024 to the range of descaling and mortality percentages observed in past years (2008–2013) separately for spring and summer:
        i. 2024 upper 1% peak efficiency range vs. 2008–2013 mid 1% peak efficiency range
        ii. 2024 mid and upper 1% peak efficiency range vs. 2008–2013 mid and upper 1% peak efficiency range
3. Conduct a pilot-scale effort to evaluate run-of-river juvenile salmonid VBS impingement during mid and upper 1% peak efficiency range operations in a corbel-modified gatewell (15A) and an unmodified (no corbel) gatewell (15C).

Methods: Fish Descaling and Mortality

- Smolt Monitoring Program
  - Daily samples in the Juvenile Monitoring Facility to estimate descaling and mortality
    - ✓No change to standard sampling protocol
      - Consistency with many years of data collection
    - ✓24-hour sample ends at 0700h
    - ✓Combine all salmonids in the sample for measures of descaling and mortality

Methods: Treatment Conditions

- Mid 1% or Upper 1% Treatments
  - Upper 1%: Near upper 1% (~within 0.5 kcfs below limit)
  - Mid 1%: 13-15 kcfs
- All operating turbines at B2 maintain treatment flow range
  - Turbines can go on or off, but maintain treatment range when on
  - Apply treatment for the 48-hour period prior to sample end at 0700h to account for fish that do not exit the bypass system within 24 hours.
  - Limit gatewell disturbances
    - ✓Conduct VBS cleaning in the earliest part of the 48-hour treatment
    - ✓Sonars or cameras in gatewell for impingement on non-treatment days

Methods: Treatment Comparison

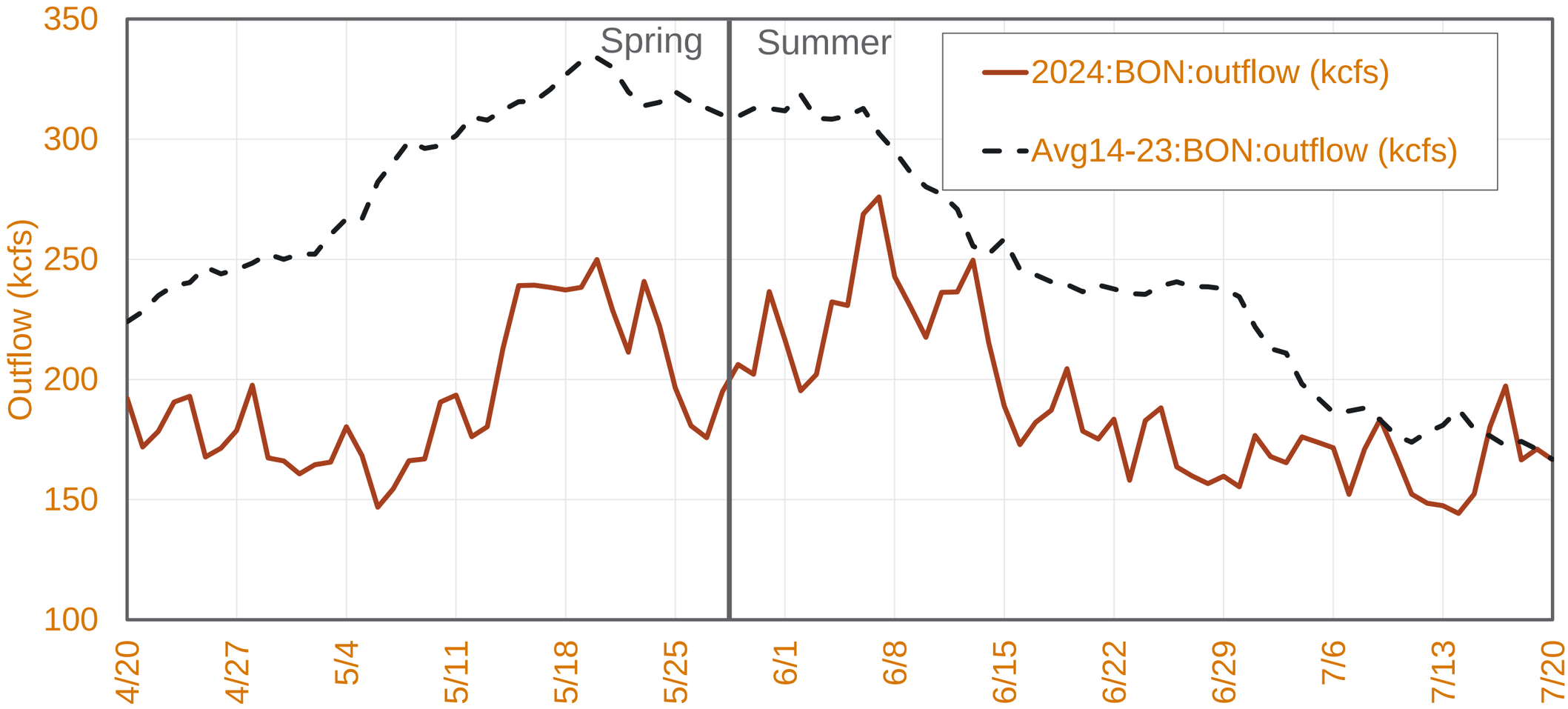
- Block study design
  - Spring and Summer
  - Treatments randomly assigned within blocks
- Sample collected for the last 24 hours of 48-hour treatment
- Contrast descaling and mortality
  - Mid 1% vs Upper 1%

Methods: Historical Comparison

Seasonal mean rates of descaling and mortality measured in 2024 treatment sample days vs weekly means for 2008 through 2013.

- Historic Mid 1%
  - SMP weeks when units operated in the mid 1% range ≥80% of the time and >100 fish were sampled
  - N= 11
- Historic Mid & Upper 1%
  - SMP weeks when units operated in the mid & upper 1% ranges ≥80% of the time and >100 fish were sampled
  - N= 25

Implementation:Low River Flow Conditions in 2024



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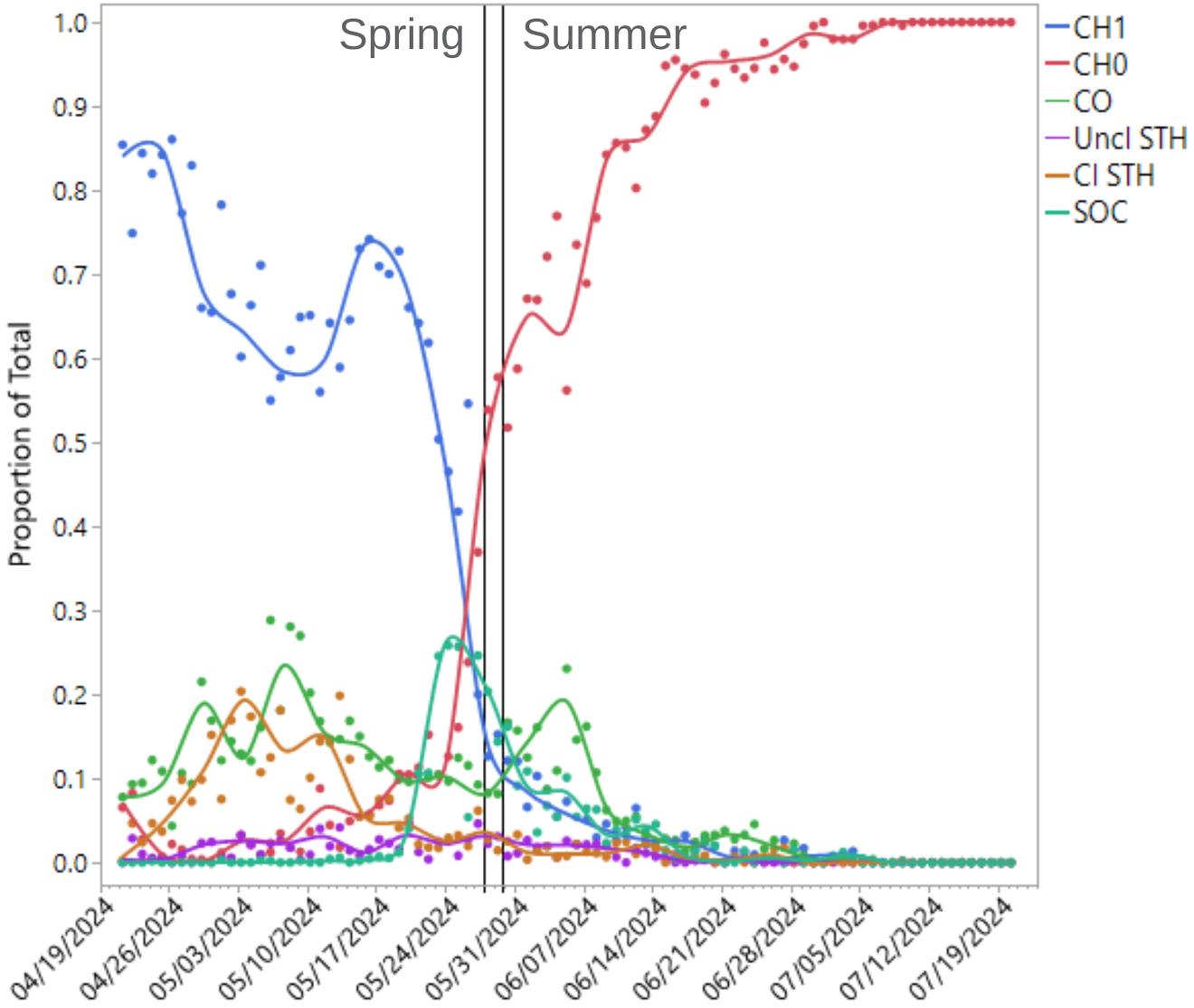
Implementation: Species Composition

- The transition from spring to fall Chinook in the SMP sample occurred earlier than expected ~5/28
- The last blocks in spring were changed to summer blocks



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Implementation: Spring Treatment Schedule Shortened

- 10 planned blocks
- Last 2 blocks dominated by summer species: Moved to summer study
- 8 blocks in spring study period

Block	SMP Sample Day	Treatment
1	4/22	Mid
1	4/24	Upper
2	4/27	Mid
2	4/29	Upper
3	5/1	Upper
3	5/4	Mid
4	5/6	Upper
4	5/8	Mid
5	5/11	Mid
5	5/13	Upper
6	5/15	Upper
6	5/18	Mid
7	5/20	Mid
7	5/22	Upper
8	5/25	Upper
8	5/27	Mid
9	5/29	Mid
9	6/1	Upper
10	6/3	Mid
10	6/5	Upper

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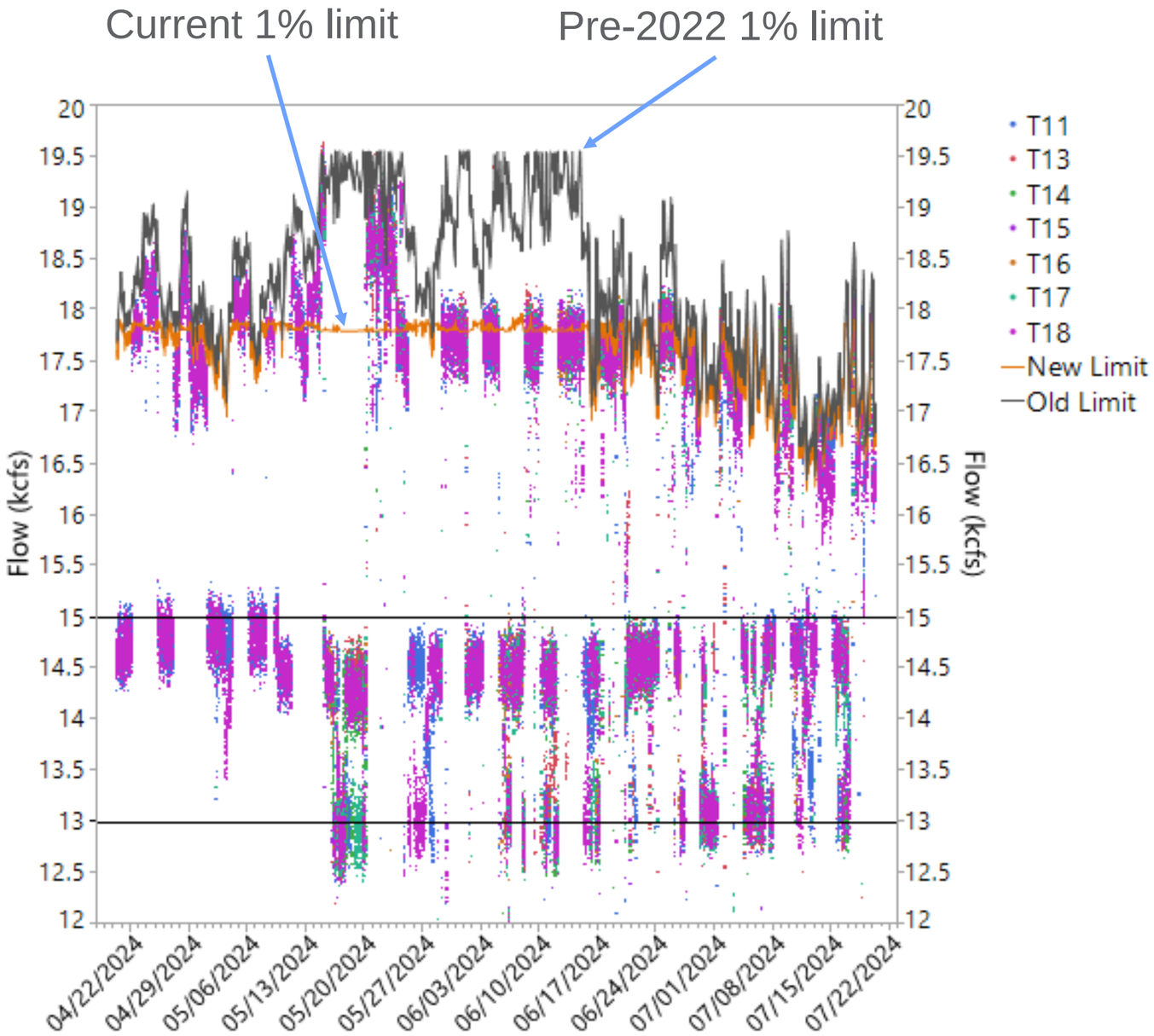
Implementation: Summer Treatment Schedule Expanded

- 9 planned blocks
- Early shift to summer species: 2 blocks added to start of season
- 11 blocks in summer study period

Block	SMP Sample Day	Treatment
-1	6/1	Upper
-1	6/3	Mid
0	6/5	Upper
0	6/8	Mid
1	6/10	Upper
1	6/12	Mid
2	6/15	Upper
2	6/17	Mid
3	6/19	Upper
3	6/22	Mid
4	6/24	Mid
4	6/26	Upper
5	6/29	Upper
5	7/1	Mid
6	7/3	Upper
6	7/6	Mid
7	7/8	Mid
7	7/10	Upper
8	7/13	Mid
8	7/15	Upper
9	7/17	Mid
9	7/20	Upper

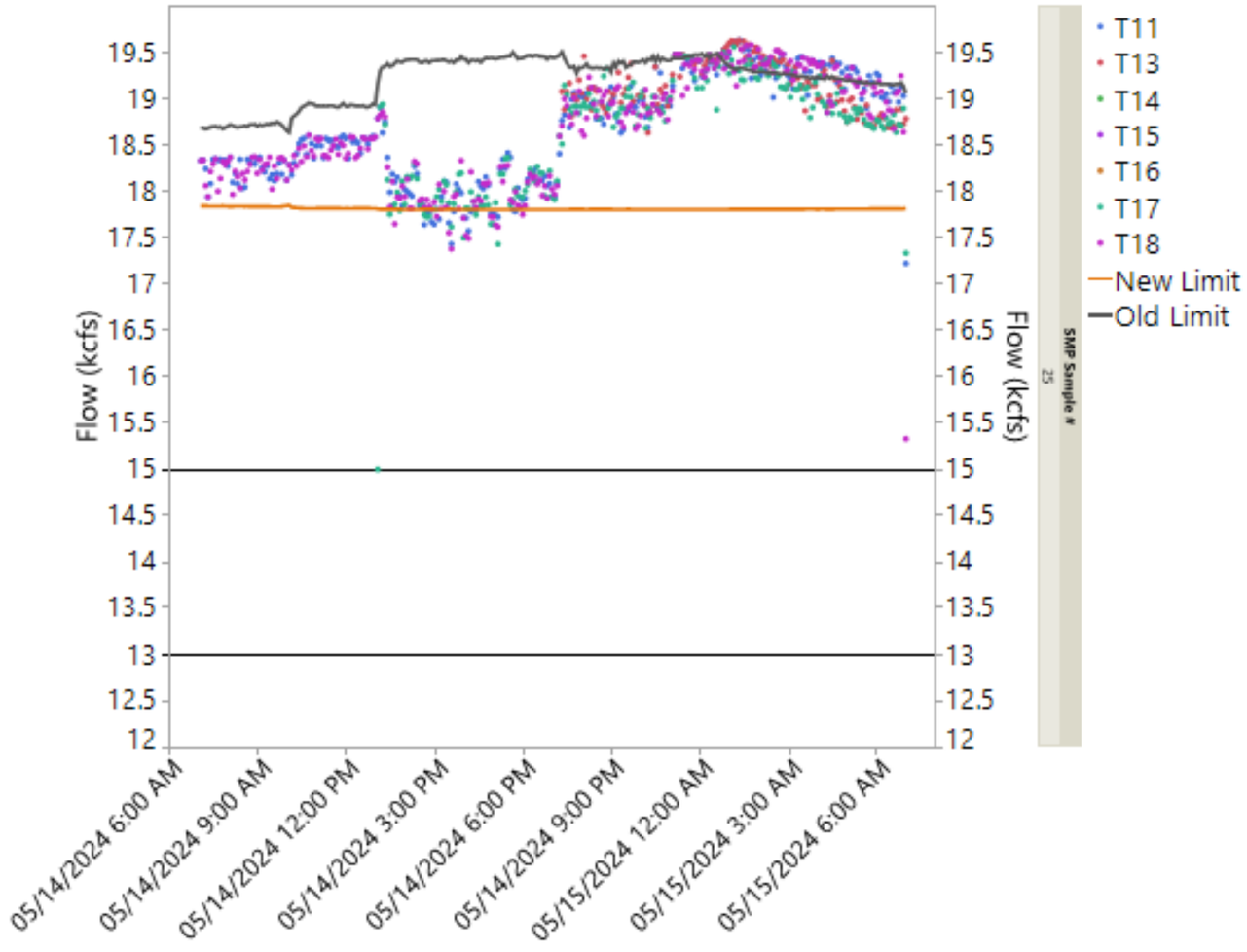
Implementation: Treatment Levels

- Flows often exceeded 1% limit in spring
  - Appeared to be following FPP table pre-2022
- Flows slightly off even in Mid 1% range
  - Forebay elevation issue
  - Correction required



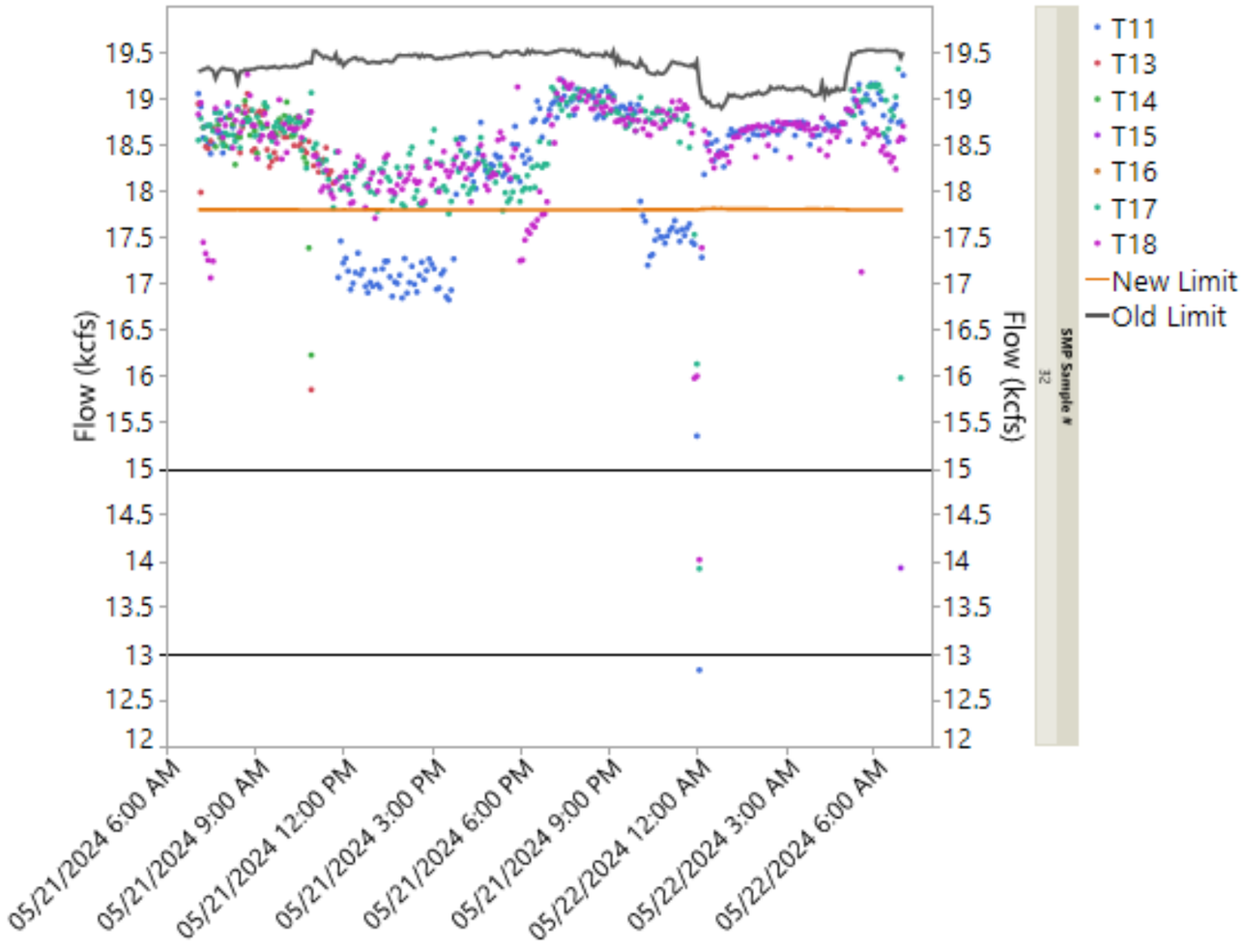
Implementation: Example Day Exceeding New Upper 1% Limit

- Old Upper 1% limit can exceed the current limit by more than 1 kcfs
- Operation well above 1% limit for some days in spring



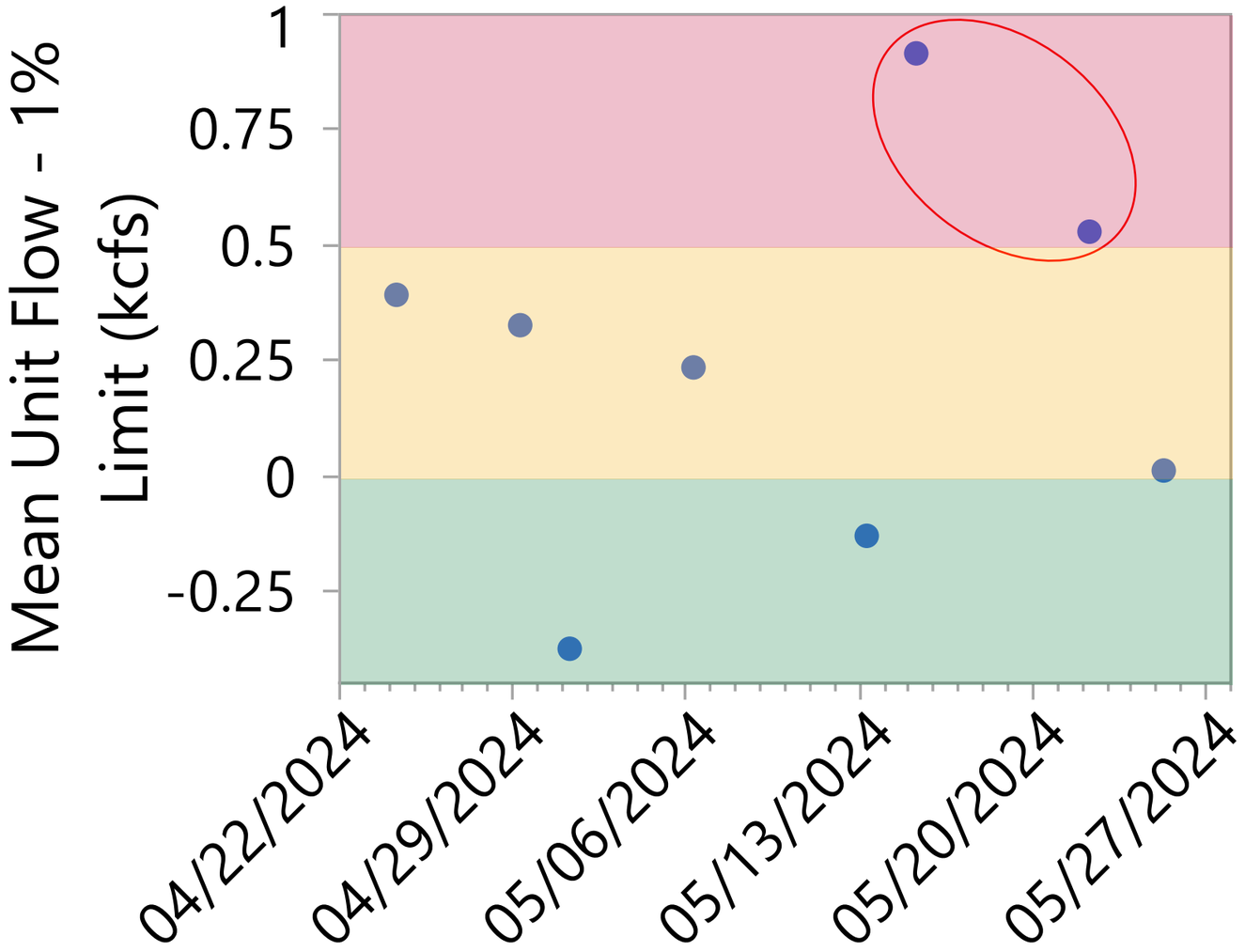
Implementation: Sensor Issues Inflate Uncertainty Around Unit Flow

- Bad readings for B2 forebay elevation sensor used to compute head and flow (treatments)
- B1 Elevation sensor used to estimate corrected flow
- Accuracy of the correction is uncertain

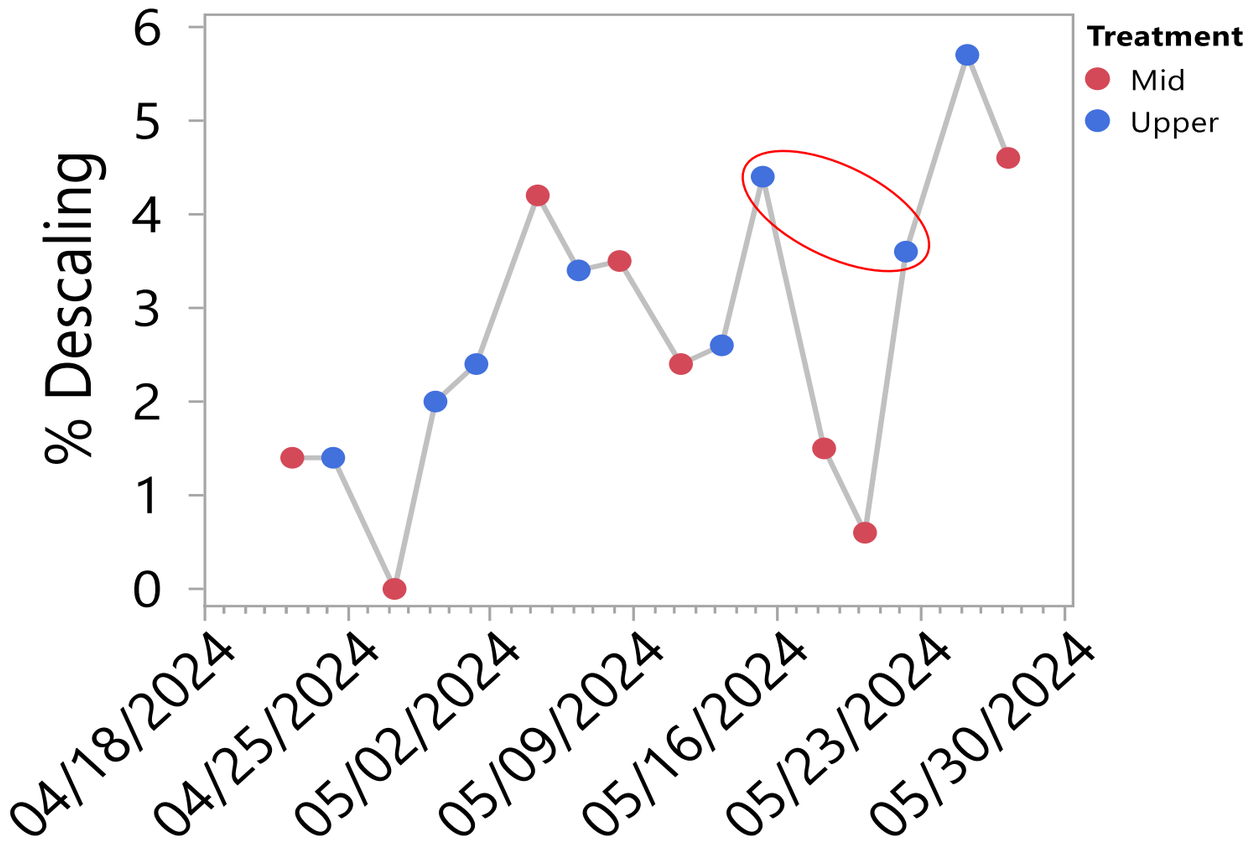


Implementation: Spring High Flow Days Censored

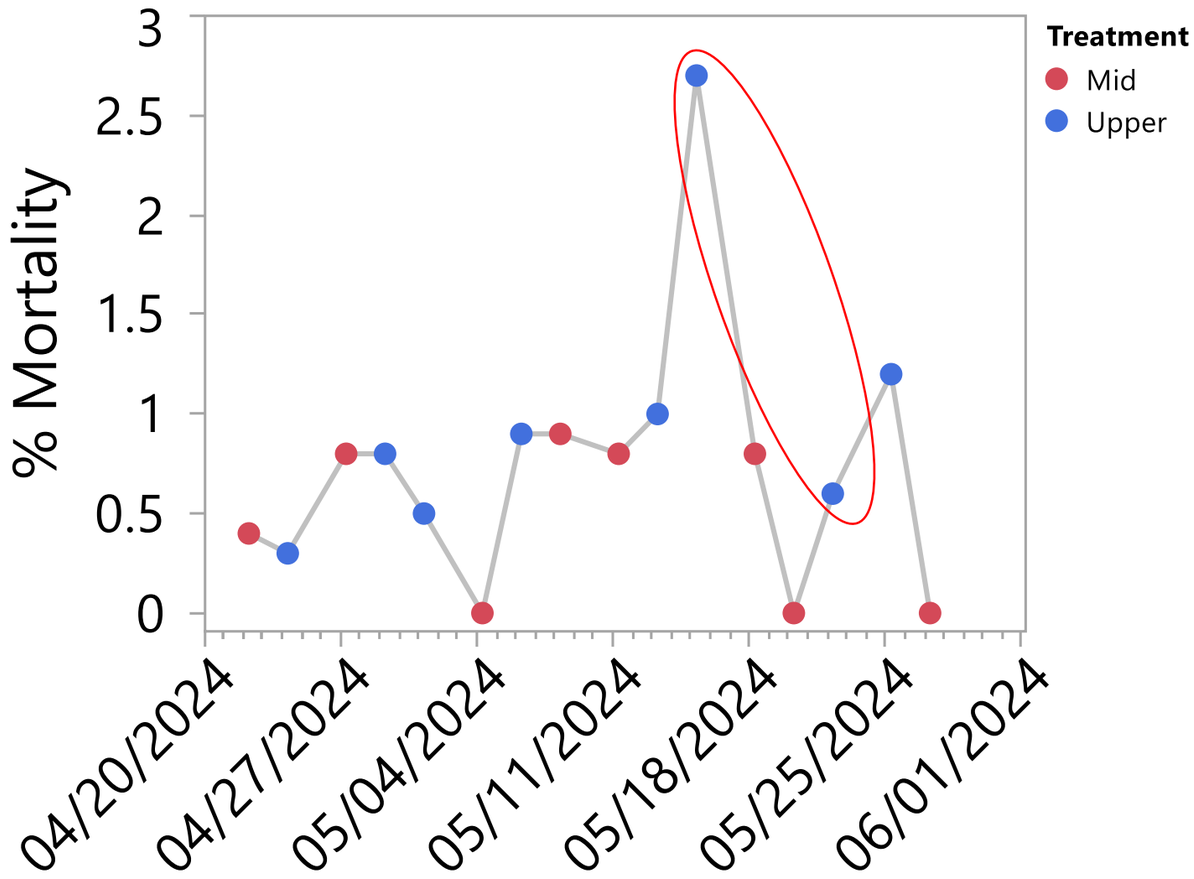
- Spring analysis done with and without high-flow blocks
  - Illustrate the influence of high-flow days
  - Show results more consistent with current upper 1% range



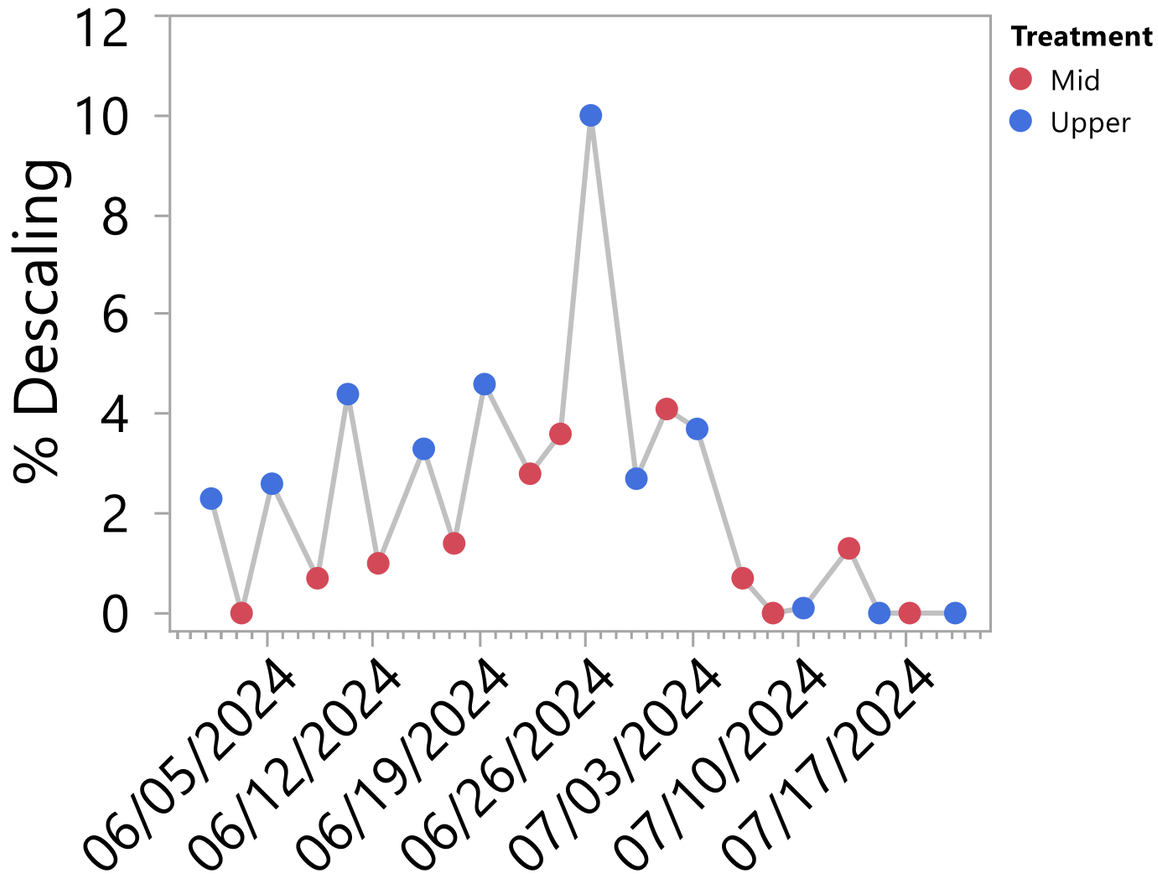
Result: Spring Treatment Comparison



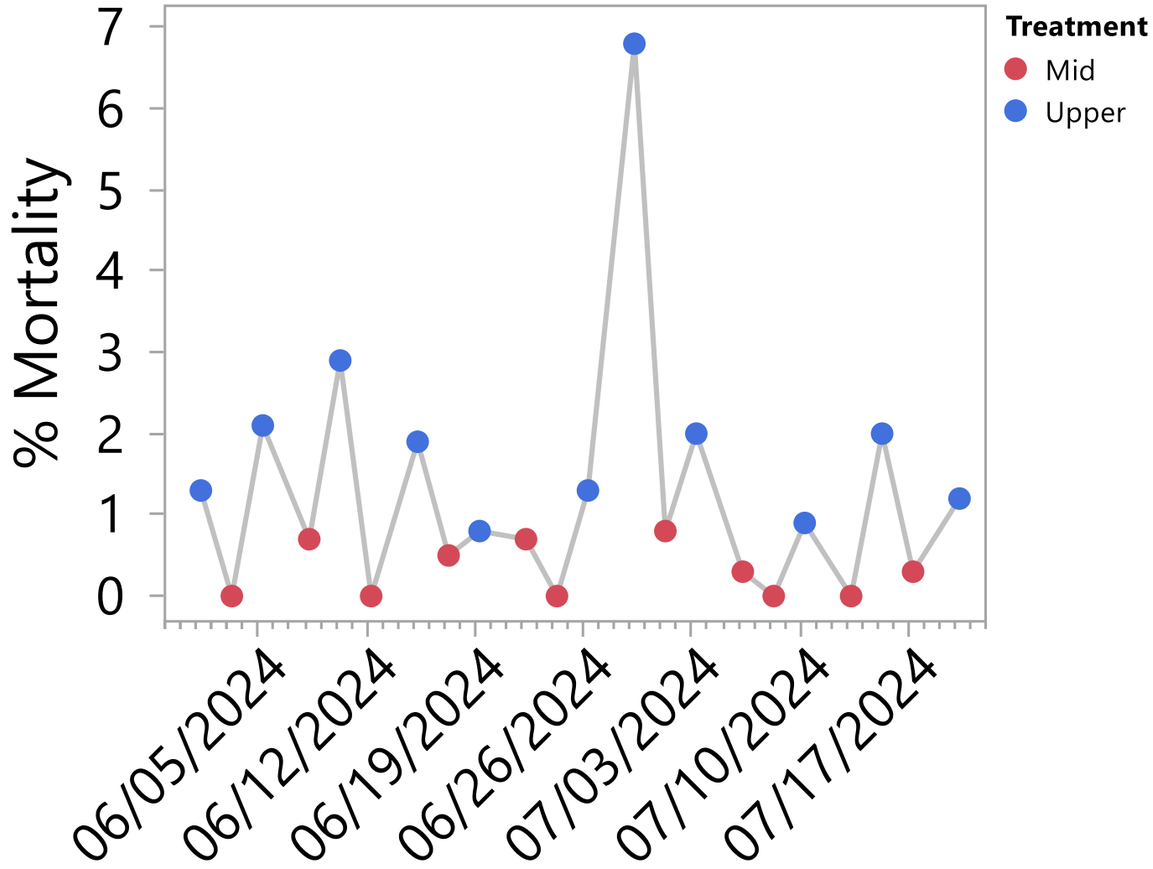
Result: Spring Treatment Comparison



Result: Summer Treatment Comparison



Result: Summer Treatment Comparison



Results:Descaling Treatment Comparison

Season	SMP days	Trtmnt	Total N	Desc N	Desc %	Cohen's h	Odds Ratio	P-Value	Power
Spring	All	Mid	1737	34	1.96%	-0.06124	0.669621	**0.04156**	0.5803
		Upper	4421	128	2.90%				
Spring	25 & 32 excluded	Mid	1737	34	1.96%	-0.03831	0.771281	0.2389	0.2534
		Upper	3329	84	2.52%				
Summer	All	Mid	2415	24	0.99%	-0.13635	0.348895	**8.15E-07**	0.9993
		Upper	3468	97	2.80%				

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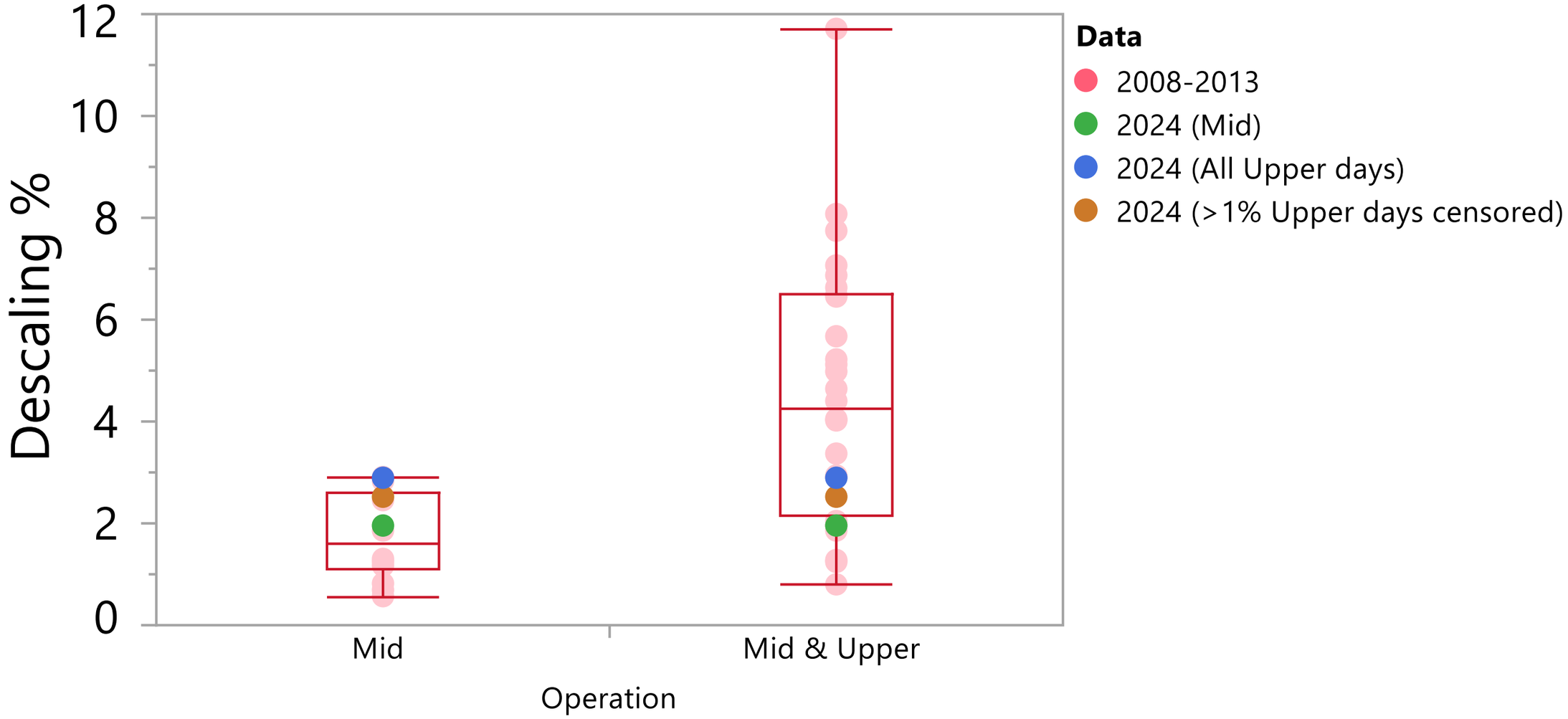
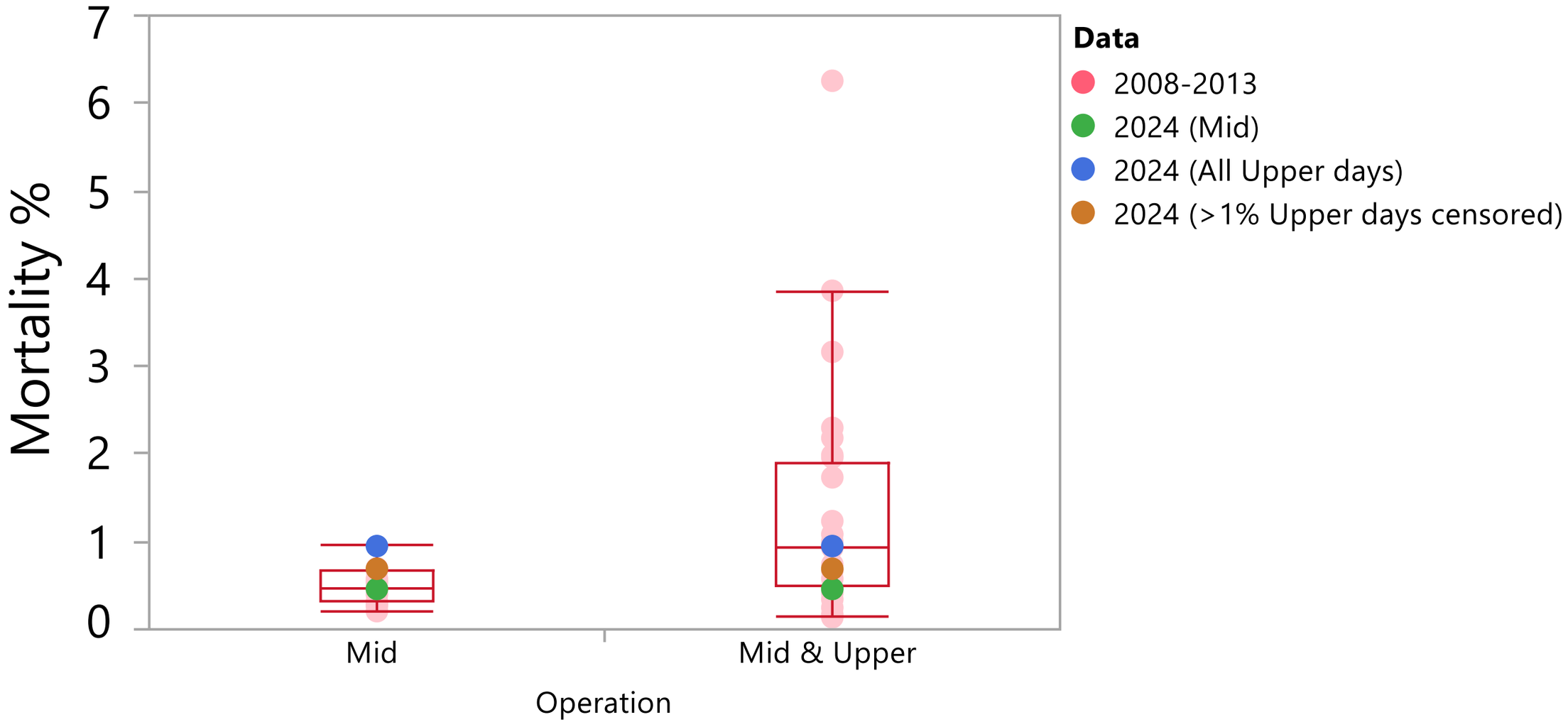
Results: Mortality Treatment Comparison

Season	SMP days	Trtmnt	Total N	Mort N	Mort %	Cohen's h	Odds Ratio	P-Value	Power
Spring	All	Mid	1737	8	0.46%	-0.05941	0.482463	0.0582	0.5549
		Upper	4421	42	0.95%				
Spring	25 & 32 excluded	Mid	1737	8	0.46%	-0.0306	0.665124	0.3502	0.1786
		Upper	3329	23	0.69%				
Summer	All	Mid	2415	8	0.33%	-0.14866	0.188823	**1.56E-07**	0.9999
		Upper	3468	60	1.73%				

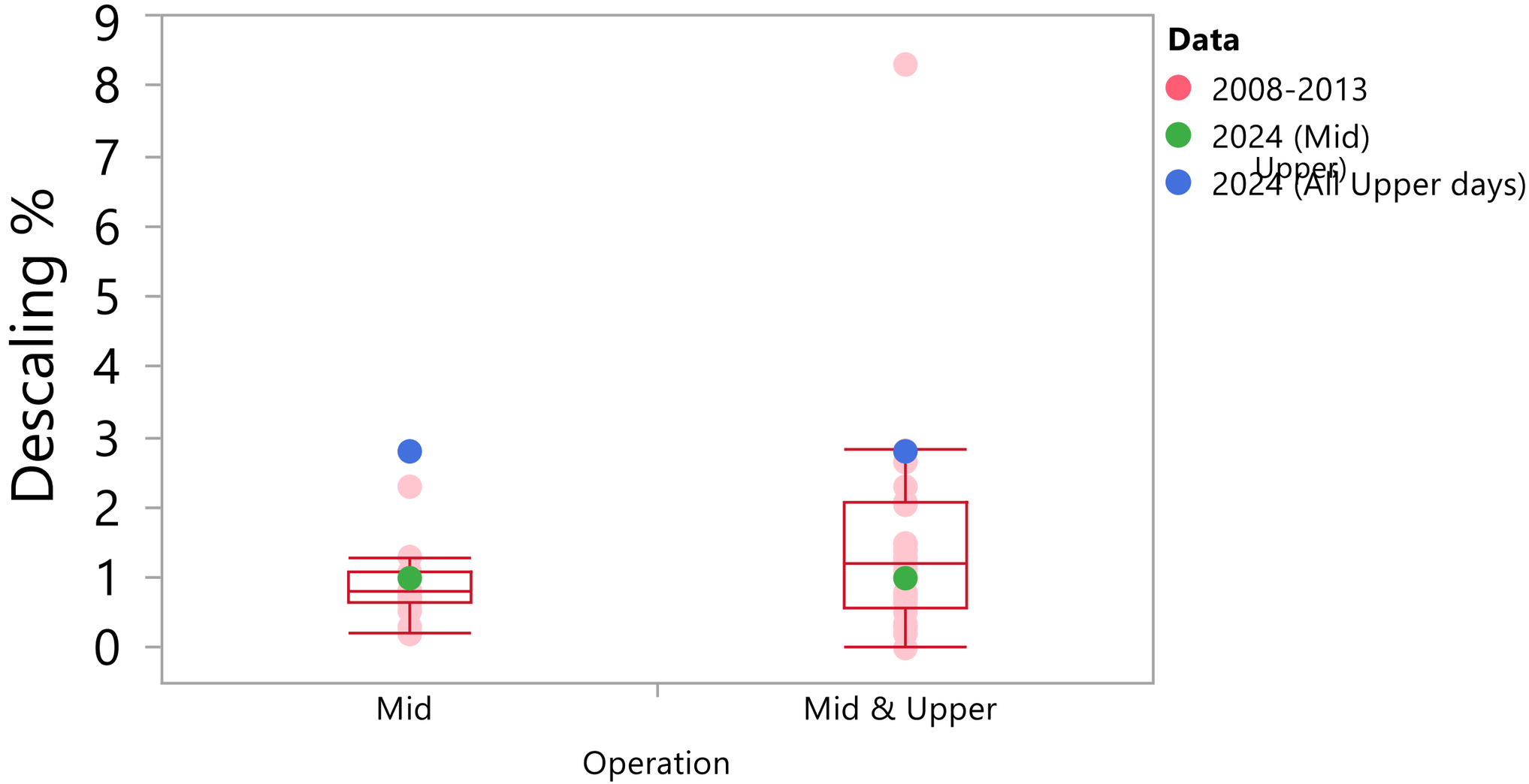
Results: Spring 2024 Comparison to Historical Descaling



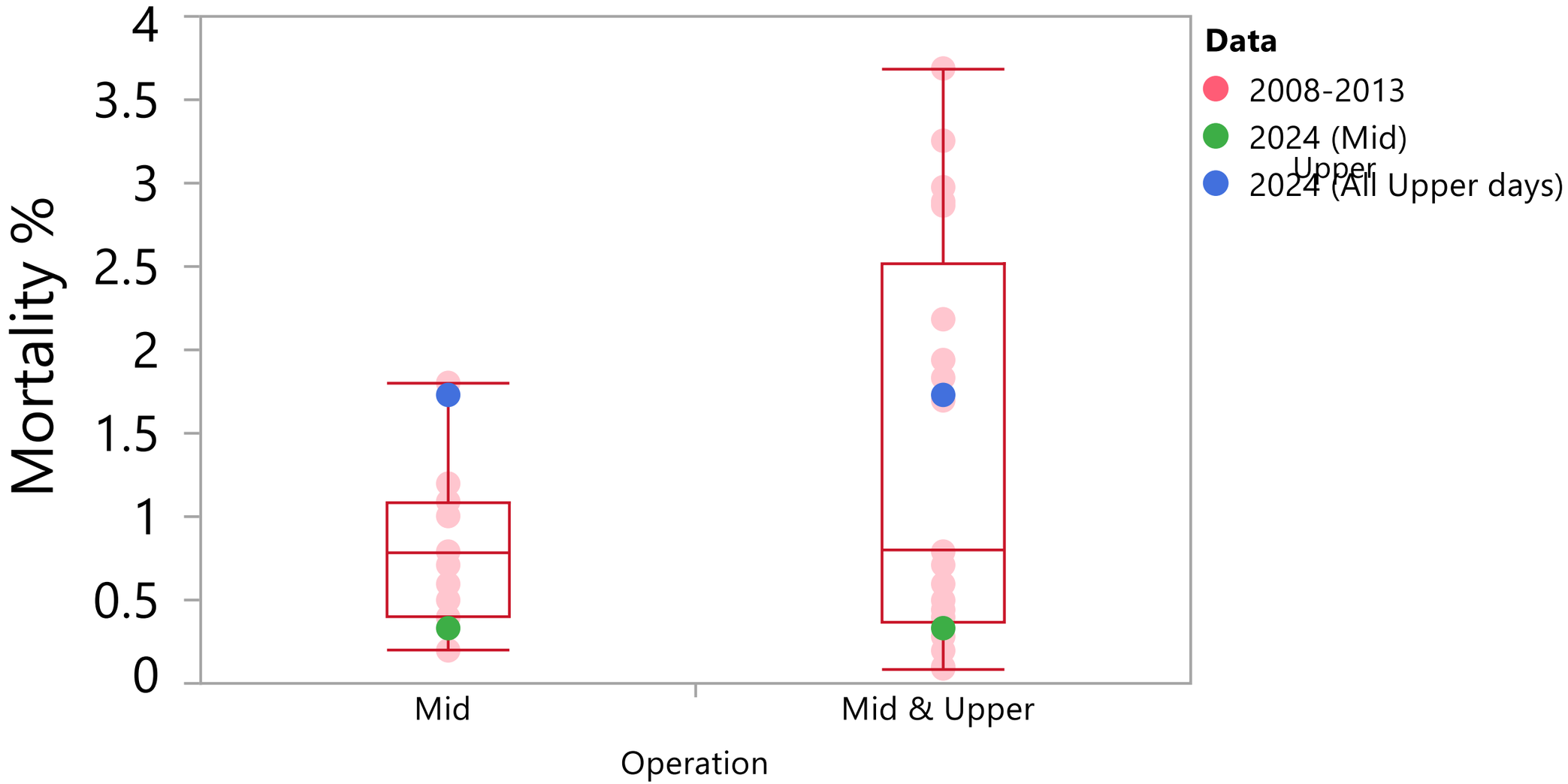
Results: Spring 2024 Comparison to Historical Mortality



Results: Summer 2024 Comparison to Historical Descaling



Results: Summer 2024 Comparison to Historical Mortality



Conclusions: Spring

- Caveats
  - Turbine discharge levels not held to treatment levels in spring
- Descaling significantly different only if days retained despite exceeding flow limits
- Mortality nearly significantly different only if days retained despite exceeding flow limits
- 2024 Upper 1% descaling and mortality fell at upper range of historic mid 1%, but were in the middle of the range for historic Mid+Upper 1% conditions

Conclusions: Summer

- Descaling and mortality significantly different between treatments during summer
- Descaling during 2024 Upper 1% was high compared to historic mid 1% range, and was near the upper range for historic Mid+Upper 1%
- Mortality during 2024 Upper 1% was near the upper range of historic mid 1% range, and was near the middle to upper range for historic Mid+Upper 1%

Next Steps

- Available for discussion with SRWG
- Report available for review in April
- Future Research Ideas
  - Repeat study
    - ✓ Avoid uncertainty from flow correction
    - ✓ Different flow year
    - ✓ Spring: Match operations to current upper 1% range
    - ✓ Summer: Reduce upper treatment range
      - Mid 1% vs a selected range between mid and upper 1%
  - Look into the implications of lower sample numbers during Mid 1%
    - ✓ How much is BON PIT detection rate reduced
    - ✓ How much is FGE reduced
    - ✓ How does that affect routing and survival and by how much

Acknowlegements

- USACE Oversight: Jon Rerecich, Becca Cates, and Brad Eppard
- Bonneville Dam: Operators, riggers, biologists, and more
- NOAA feedback: Trevor Conder

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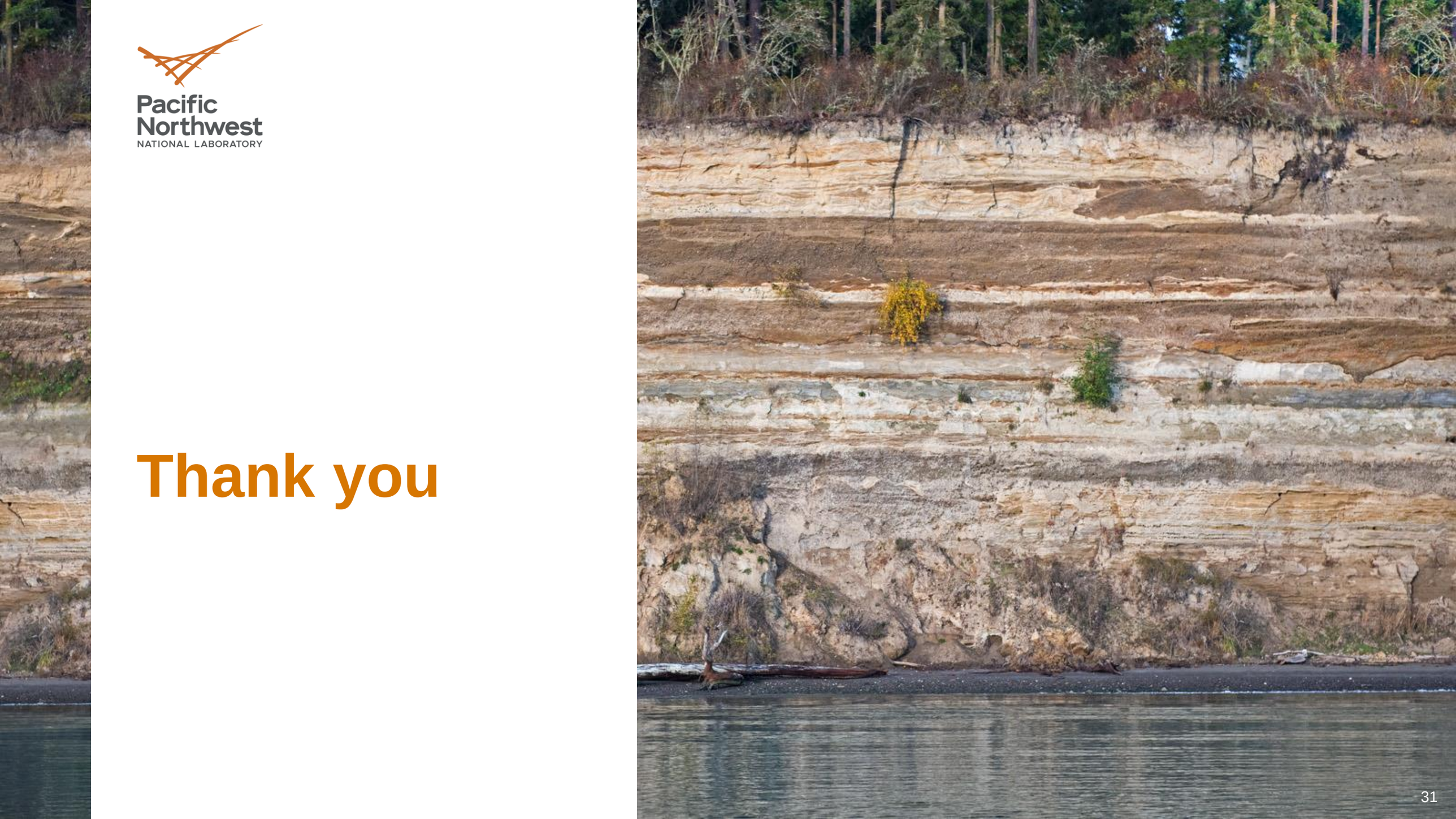
Thank you



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Additional Materials Follow

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1% Peak Efficiency Changed in FPP

2021 Fish Passage Plan — Bonneville Dam — Last Updated: 11-MAR-2021

Project Head (ft)	PH2 Units 11–18 With STS						PH2 Units 11–18 No STS					
	1% Lower Limit		1% Upper Limit		Operating Limit [b]		1% Lower Limit		1% Upper Limit		Operating Limit [b]	
	MW	cfs	MW	cfs	MW	cfs	MW	cfs	MW	cfs	MW	cfs
35	27.6	11,259	44.3	18,068	46.7	19,283	28.2	11,444	45.1	18,277	46.7	19,168
36	28.5	11,271	45.8	18,097	49.0	19,714	29.2	11,455	46.6	18,306	49.0	19,597
37	29.4	11,279	47.3	18,121	51.4	20,146	30.1	11,464	48.1	18,331	51.4	20,026
38	30.3	11,284	48.8	18,139	53.9	20,580	31.0	11,470	49.7	18,350	53.9	20,457
39	31.3	11,287	50.3	18,153	56.4	21,014	32.0	11,473	51.2	18,364	56.4	20,889
40	32.2	11,288	51.8	18,162	59.0	21,450	32.9	11,474	52.7	18,374	59.0	21,321
41	33.0	11,259	53.3	18,197	61.2	21,654	33.7	11,445	54.3	18,409	61.2	21,535
42	33.8	11,230	54.9	18,228	63.4	21,854	34.6	11,415	55.8	18,441	63.4	21,744
43	34.6	11,201	56.4	18,255	65.6	22,049	35.4	11,386	57.4	18,468	65.6	21,949
44	35.4	11,172	57.9	18,278	67.8	22,240	36.2	11,357	58.9	18,493	67.8	22,150
45	36.2	11,144	59.4	18,299	70.1	22,427	37.0	11,328	60.5	18,514	70.1	22,347
46	37.0	11,139	61.0	18,366	72.1	22,441	37.9	11,324	62.1	18,581	72.1	22,390
47	37.8	11,135	61.9	18,200	74.2	22,450	38.7	11,319	63.0	18,415	74.2	22,429
48	38.7	11,129	62.7	18,040	76.3	22,455	39.6	11,314	63.8	18,255	76.3	22,463
49	39.5	11,124	63.5	17,887	76.5	21,994	40.4	11,308	64.7	18,101	76.5	22,040
50	40.3	11,118	67.5	18,598	76.5	21,497	41.3	11,303	68.7	18,817	76.5	21,527
51	41.3	11,154	69.8	18,850	76.5	20,999	42.2	11,339	71.1	19,072	76.5	21,015
52	42.3	11,187	72.1	19,091	76.5	20,502	43.2	11,373	73.4	19,316	76.5	20,502
53	43.2	11,219	74.5	19,323	76.5	20,005	44.2	11,405	75.8	19,551	76.5	19,989
54	44.2	11,249	76.8	19,545	76.5	19,536	45.2	11,436	78.2	19,775	76.5	19,431
55	45.2	11,278	79.1	19,758	76.5	19,115	46.2	11,466	80.5	19,991	76.5	18,975
56	46.4	11,343	79.5	19,455	76.5	18,718	47.4	11,531	80.9	19,685	76.5	18,581
57	47.6	11,404	79.9	19,162	76.5	18,336	48.6	11,593	81.4	19,389	76.5	18,202
58	48.8	11,461	80.3	18,880	76.5	17,967	49.9	11,652	81.8	19,103	76.5	17,836
59	50.0	11,515	80.7	18,606	76.5	17,611	51.1	11,707	82.2	18,827	76.5	17,483
60	51.2	11,567	81.1	18,342	76.5	17,267	52.3	11,760	82.6	18,559	76.5	17,142
61	51.8	11,532	84.7	18,854	76.5	16,978	53.0	11,724	86.2	19,078	76.5	16,857
62	52.5	11,498	88.3	19,352	76.5	16,699	53.7	11,690	89.9	19,582	76.5	16,582
63	53.1	11,466	91.9	19,836	76.5	16,428	54.3	11,657	93.5	20,071	76.5	16,315
64	53.7	11,434	95.4	20,306	76.5	16,166	55.0	11,625	97.2	20,546	76.5	16,056
65	54.4	11,405	99.0	20,762	76.5	15,912	55.6	11,595	100.8	21,008	76.5	15,806
66	55.4	11,448	100.6	20,769	76.5	15,671	56.7	11,639	102.4	21,015	76.5	15,570
67	56.5	11,490	102.1	20,776	76.5	15,437	57.8	11,682	104.0	21,022	76.5	15,341
68	57.5	11,532	103.7	20,783	76.5	15,210	58.9	11,724	105.6	21,029	76.5	15,119
69	58.6	11,571	105.3	20,790	76.5	14,990	59.9	11,764	107.2	21,036	76.5	14,903
70	59.6	11,610	106.8	20,796	76.5	14,775	61.0	11,803	108.7	21,042	76.5	14,693

a. Values provided by HDC (Jun 2000), except PH1 BOP from Turbine Survival Program (TSP) modeling and analysis (Jan 2013). Flow (cfs) was calculated based on turbine efficiency, project head, and power output (MW).

b. "Operating Limit" (added Feb 2018) is the maximum safe operating point based on cavitation or generator limit. BON PH2 units have a generator limit that restricts turbine output at higher heads. Values shaded in gray indicate the Operating Limit is below the 1% Upper Limit.

2022 Fish Passage Plan — Bonneville Dam — VERSION: 15-JUN-2022

Project Head (ft)	PH2 Units 11–18 With STS						PH2 Units 11–18 No STS					
	1% Lower Limit		1% Upper Limit		Operating Limit [b]		1% Lower Limit		1% Upper Limit		Operating Limit [b]	
	MW	cfs	MW	cfs	MW	cfs	MW	cfs	MW	cfs	MW	cfs
35	30.8	12,470	38.0	15,397	41.0	16,921	31.2	12,500	38.5	15,402	44.4	18,465
36	31.7	12,462	39.9	15,671	42.5	16,972	32.3	12,524	40.3	15,630	46.5	18,741
37	32.7	12,456	41.8	15,939	44.3	17,131	33.3	12,542	42.2	15,875	48.6	19,000
38	33.6	12,419	43.8	16,212	46.3	17,347	34.3	12,534	44.1	16,122	50.7	19,257
39	34.4	12,359	45.8	16,472	48.2	17,543	35.3	12,516	46.1	16,350	52.9	19,512
40	35.1	12,271	47.8	16,728	50.2	17,744	36.2	12,469	48.1	16,591	55.1	19,765
41	35.8	12,169	49.9	16,973	52.3	17,947	37.0	12,401	50.2	16,824	57.4	20,000
42	36.4	12,050	51.9	17,216	54.3	18,152	37.7	12,307	52.3	17,057	59.6	20,222
43	37.0	11,932	54.0	17,447	56.4	18,353	38.4	12,192	54.4	17,289	61.9	20,433
44	37.6	11,829	56.1	17,657	58.5	18,544	39.0	12,069	56.6	17,519	64.1	20,646
45	38.2	11,741	58.1	17,839	60.7	18,730	39.6	11,950	58.8	17,743	66.4	20,844
46	39.0	11,673	60.0	17,982	62.8	18,914	40.2	11,843	61.0	17,962	68.7	21,039
47	39.8	11,624	61.8	18,064	64.9	19,091	40.9	11,753	63.2	18,171	71.0	21,229
48	40.6	11,593	63.3	18,072	67.1	19,257	41.6	11,680	65.4	18,360	73.2	21,399
49	41.5	11,571	64.7	18,031	69.2	19,422	42.4	11,625	67.4	18,508	75.5	21,563
50	42.4	11,557	65.9	17,941	70.4	19,289	43.2	11,594	69.2	18,569	76.5	21,172
51	43.3	11,545	67.0	17,852	71.6	19,173	44.1	11,580	70.8	18,566	76.5	20,528
52	44.2	11,540	68.3	17,814	72.7	19,079	45.1	11,577	72.1	18,519	76.5	19,918
53	45.1	11,540	69.6	17,803	73.9	19,001	46.0	11,574	73.3	18,445	76.5	19,384
54	46.0	11,532	71.0	17,800	75.1	18,912	46.9	11,567	74.4	18,353	76.5	18,925
55	46.9	11,517	72.5	17,808	76.3	18,830	47.8	11,553	75.5	18,243	76.5	18,515
56	47.7	11,501	74.0	17,832	76.5	18,489	48.7	11,539	76.5	18,139	76.5	18,133
57	48.6	11,491	75.6	17,882	76.5	18,117	49.6	11,530	77.6	18,067	76.5	17,771
58	49.4	11,490	77.3	17,968	76.5	17,766	50.5	11,529	79.1	18,064	76.5	17,426
59	50.3	11,500	79.2	18,093	76.5	17,435	51.4	11,542	80.7	18,127	76.5	17,097
60	51.2	11,521	81.1	18,241	76.5	17,122	52.4	11,568	82.6	18,237	76.5	16,786
61	52.1	11,535	81.9	18,121	76.5	16,843	53.3	11,580	83.6	18,160	76.5	16,504
62	53.0	11,548	82.6	18,008	76.5	16,577	54.2	11,587	84.6	18,102	76.5	16,234
63	53.8	11,561	83.3	17,888	76.5	16,322	55.0	11,592	85.7	18,055	76.5	15,978
64	54.7	11,570	84.0	17,773	76.5	16,078	55.9	11,601	86.9	18,027	76.5	15,735
65	55.5	11,576	84.6	17,662	76.5	15,844	56.8	11,608	88.1	18,022	76.5	15,502
66	56.3	11,579	85.3	17,562	76.5	15,620	57.6	11,612	89.4	18,038	76.5	15,279
67	57.0	11,574	86.0	17,469	76.5	15,407	58.4	11,613	90.9	18,080	76.5	15,066
68	57.7	11,562	86.7	17,375	76.5	15,203	59.1	11,609	92.5	18,152	76.5	14,862
69	58.3	11,537	87.3	17,285	76.5	15,008	59.9	11,598	94.2	18,247	76.5	14,665
70	58.8	11,505	88.0	17,205	76.5	14,818	60.6	11,586	96.0	18,361	76.5	14,476

a. Values provided by HDC (May 2022), except PH1 BOP from Turbine Survival Program (TSP) modeling and analysis (Jan 2013). Flow (cfs) is a calculated value based on turbine efficiency, project head, and power output (MW).

b. "*Operating Limit*" (added Feb 2018) is the maximum safe operating point based on cavitation or generator limit. BON PH2 units have a generator limit that restricts turbine output at higher heads. Values shaded in gray indicate the Operating Limit is below the modeled 1% Upper Limit.

Results: Spring Descaling And Mortality by Block

SMP Sample Date	Block	Treatment	% Desc	% Mort	Total sampled
4/22/2024	1	Mid	1.4	0.4	279
4/24/2024	1	Upper	1.4	0.3	772
4/27/2024	2	Mid	0	0.8	132
4/29/2024	2	Upper	2	0.8	609
5/1/2024	3	Upper	2.4	0.5	626
5/4/2024	3	Mid	4.2	0	190
5/6/2024	4	Upper	3.4	0.9	569
5/8/2024	4	Mid	3.5	0.9	228
5/11/2024	5	Mid	2.4	0.8	125
5/13/2024	5	Upper	2.6	1	504
5/15/2024	6	Upper	4.4	2.7	586
5/18/2024	6	Mid	1.5	0.8	394
5/20/2024	7	Mid	0.6	0	324
5/22/2024	7	Upper	3.6	0.6	506
5/25/2024	8	Upper	5.7	1.2	249
5/27/2024	8	Mid	4.6	0	65

Results: Summer Descaling And Mortality by Block

SMP Sample Date	Block	Treatment	% Desc	% Mort	Total sampled
6/1/2024	-1	Upper	2.3	1.3	304
6/3/2024	-1	Mid	0	0	104
6/5/2024	0	Upper	2.6	2.1	386
6/8/2024	0	Mid	0.7	0.7	271
6/10/2024	1	Upper	4.4	2.9	306
6/12/2024	1	Mid	1	0	294
6/15/2024	2	Upper	3.3	1.9	213
6/17/2024	2	Mid	1.4	0.5	218
6/19/2024	3	Upper	4.6	0.8	376
6/22/2024	3	Mid	2.8	0.7	145
6/24/2024	4	Mid	3.6	0	110
6/26/2024	4	Upper	10	1.3	304
6/29/2024	5	Upper	2.7	6.8	118
7/1/2024	5	Mid	4.1	0.8	122
7/3/2024	6	Upper	3.7	2	248
7/6/2024	6	Mid	0.7	0.3	308
7/8/2024	7	Mid	0	0	93
7/10/2024	7	Upper	0.1	0.9	697
7/13/2024	8	Mid	1.3	0	80
7/15/2024	8	Upper	0	2	350
7/17/2024	9	Mid	0	0.3	670
7/20/2024	9	Upper	0	1.2	166